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INTEROFFICE CORRESPONDENCE

DATE: November 22, 1995

TO: E. C. Mast, Environmental Projects Group, Bldg. 080, x8589

FROM: R. G. Smith, Jr., Hydrogeology, Bldg. T893B, x7898

SUBJECT: SUMMARY OF GEOLOGIC AND HYDROGEOLOGIC CONDITIONS AT THE INDUSTRIAL AREA WEST SITE - RGS-014-95

At your request, I have prepared a brief summary of the geologic and hydrogeologic conditions for the Industrial Area West (IAW) site. My examination of the available database indicates that there is an adequate amount of geologic and hydrogeologic data for Waste Management Facility (WMF) siting and monitoring program design purposes. Additional compliance monitoring wells may, however, be required to fill data gaps related to certain unmonitored flow paths and replace existing wells equipped with improperly placed screens. These deficiencies are discussed in the last section of the memorandum.

Two hydrologic features of the site that may impact WMF design and siting deserve special attention. These features include a seasonally shallow depth to groundwater and short flow path distances to nearby seepage areas in the Woman Creek drainage. More detail of these features is given below.

The majority of information gathered for this summary came from the 1995 Site-wide Geologic and Hydrogeologic Characterization Reports.

Lithology and Geologic Structure

The proposed WMF is situated in an upland area occupied entirely by the Rocky Flats alluvium and flanked to the south by the colluvium-covered valley slope of the Woman Creek drainage. The composition of the Rocky Flats alluvium at the site is typical of most areas at RFETS with clayey and silty sand and gravels comprising the bulk of the underlying unconsolidated material. Bedrock materials consist chiefly of weathered and unweathered claystone and silty claystone with discontinuous beds of siltstone and fine-grained sandstone occurring at depth. Subcropping bedrock sandstone units are not evident in any of the lithologic logs at the site. Two segments of hydrogeologic cross-sections that traverse the IAW site in east-west (section G-G') and north-south (B-B') directions illustrate the local geologic and hydrogeologic settings, as presented in Figures 1 and 2, respectively.

Aspects of the geologic structure that are most relevant to the IAW site include an inferred north-south oriented bedrock fault, which, based on recent drilling at OU5, traverses the Building 460 area east of the site, and the configuration of the bedrock surface. The location of the fault in a hydraulically downgradient direction from the IAW site represents a potential groundwater pathway to deeper sections of the Laramie formation and may affect the geotechnical design criteria. A preliminary evaluation of potential vertical groundwater movement along fault zones at RFETS using environmental isotopes as hydrologic tracers has indicated that fault zones probably transmit little, if any, groundwater preferentially downward relative to flow in undisturbed, unweathered bedrock zones (memorandum to A. Primrose from R. Smith dated November 22, 1995). The influence of bedrock topography on groundwater flow is probably less significant than other regions of the industrial area where the alluvium is more thinly saturated.

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Depth to Bedrock

The depth to bedrock ranges from 25.2 feet at the south center of the site (well P416489) to 40 feet in the west center area at boring 42592. The average depth to bedrock is approximately 30 feet based on the results of nine wells and boreholes positioned at the site. Figure 3, Depth to Bedrock and Alluvial Isopach Map, illustrates the position of these borings and alluvial isopach configuration at the IAW site.

Groundwater Occurrence and Distribution

Groundwater has been found in all hydrostratigraphic units underlying the site, however only the unconsolidated surficial deposits (Rocky Flats alluvium and colluvium) and the weathered bedrock zone are considered permeable enough to facilitate significant contaminant transport. Groundwater movement in the surficial deposits occurs mainly as intergranular flow while fracture flow is assumed to predominate in weathered bedrock when it consists of claystones and other consolidated fine-grained media.

The Rocky Flats alluvium underlies the entire area of the IAW site and is continuously saturated. Recharge of alluvial materials occurs from the infiltration of precipitation and surface runoff in areas of bare soils. At the IAW site, the northwest and southwest quadrants of the site consist of bare soil areas and the southeast area is occupied by a paved parking lot for a nearby trailer complex. Discharge of alluvial groundwater to the Woman Creek drainage occurs as subsurface flow through hillside colluvial materials and as seeps, which punctuate the hillside in as many as 10 locations south of the site. Many seepages occur at elevations (6010 to 6020 feet amsl) which coincide with the projected top of bedrock surface elevations in this area.

The weathered bedrock is assumed to be fully saturated and laterally continuous. Weathered bedrock is expected to play a minor role as a contaminant pathway due in part to the thickness of the overlying saturated alluvium. It is likely that any contaminants released from a WMF would be detected first by alluvial monitoring wells. Flow in fractured claystones is probably minimal due to low hydraulic conductivities and low horizontal hydraulic gradients.

Saturated Thickness

Figure 4, Alluvial Saturated Thickness Map, indicates that the saturated thickness for surficial deposits at the IAW site varies from about 5 feet to about 30 feet (April 1993). Areas of thinner saturation are found along the southern boundary near the edge of the Rocky Flats alluvium, particularly at the southeast corner (well P416589). The thicker areas are found to the northwest near Buildings 131 and the heliport.

After reviewing the available 1995 site-wide geologic and hydrogeologic maps, the pattern of saturated thickness contours appear to be controlled more by proximity to the Woman Creek drainage than by bedrock topography. For example, the bedrock surface at well P416489 is about 15 feet higher than at well P416589, which, if bedrock controlled, would result in a thinner saturated thickness compared to P416589. The opposite of this expected result is actually observed in the data. The presence of hillside seeps and the existence of a southerly component of groundwater flow (described below) indicate discharge from the alluvium to the drainage.

Water Table Fluctuations and Historical Highs

Annual fluctuations of the alluvial water table at the IAW site typically range from 7 to 10 feet with an extreme of 16 to 17 feet observed in some wells during the spring of 1995. These fluctuations indicate that the surficial deposits in this area are very responsive to recharge events and are hydrologically active. Although unexpectedly high, the magnitude of the spring 1995 water level response in wells at the IAW site is within the range of observed responses recorded elsewhere on plant site for this same time period. Construction of a WMF in this area would likely cause a minimal reduction in the degree of water table fluctuation because the site occupies a small area of the total surrounding recharge area.

Minimum depths to water (historical highs) were recorded during or estimated for June 1995. Measured and estimated peak groundwater levels during this period ranged from 0.0 to 8.7 feet below ground level as shown in Figure 5. Wells monitored monthly for water levels during 1995 included P415889 and P416489. Monthly water levels missing from the records of quarterly monitored wells (P415989, P416089, P416189, and P416289) were estimated from linear regression analyses based on a nearby, similarly constructed reference well (P415889 - see attached correlation graphs). Correlation coefficients ranging from 0.74 (well P416289) to 0.96 (well P415989) indicate a strong correlation between the water level responses for these wells and well P415889, thus adding confidence to the estimated values. Updated hydrographs for these individual wells are also provided as attachments.

Interpretation of water level responses at the IAW site is potentially complicated by the use of this area for excess snow disposal. Local groundwater mounding due to snow pile melt recharge is postulated to occur following significant snow storm events. This practice may explain the height of some peaks, such as that associated with a major snow storm which caused a temporary plant closure in March 1992. The June 1995 peak is, however, most likely the result of natural recharge from incident precipitation and runoff rather than snow pile melting, as the 1995 spring precipitation consisted mainly of rain mixed with some light snow falls. Spring precipitation for 1995 has been estimated to be the wettest in a 102 year period based on precipitation records from Boulder, Colorado.

The deeper water levels tend to occur along the northern, western and southern boundaries of the IAW site. Shallower groundwater (wells P415989, P416089 and P416189) is found toward the center and north center.

Groundwater Flow Direction and Velocity

<u>Horizontal</u>

As illustrated in Figure 6, alluvial groundwater at the IAW site flows primarily to the east and southeast toward the industrial area and Woman Creek drainage with an additional smaller component of flow toward the northeast at the north boundary.

Consideration of the site layout, groundwater flow direction and seep occurrences in Woman Creek indicate that the shortest flow path to a discharge point is about 250 feet (seep south of well P416589). Assuming a conservative range in hydraulic conductivity values of between 4.5×10^{-4} cm/sec (1.3 ft/day) and 2.0×10^{-3} cm/sec (5.7 ft/day), a hydraulic gradient of 0.04, an effective porosity of 0.1, and no retardation; a groundwater velocity range of 0.52 ft/day (190 ft/yr) to 2.28 ft/day (832 ft/yr) is estimated as a worst case scenario. These high velocities represent a concern because of the difficulties involved with detecting contaminant releases in time to implement remedial actions prior to discharge.

Horizontal groundwater flow is also possible in the weathered bedrock which subcrops beneath the alluvium. The role of weathered bedrock as a potential transport pathway is believed to be minor relative to the overlying alluvium.

Vertical

Downward vertical groundwater flow is inferred to occur from the alluvium to the weathered bedrock at the IAW site, but is thought to be limited relative to lateral flow. The apparent lack of subcropping sandstones beneath the site supports the contention that vertical flow is limited.

Aquifer Properties

Values for alluvial hydraulic conductivity exist for all wells in the IAW site area. These values are presented below.

Well No.	Hydraulic Conductivity (cm/sec)
P415889	2.13×10^{-3}
P415989	2.85×10^{-3}
P416089	2.39×10^{-4}
P416189	5.59×10^{-3}
P416289	7.62×10^{-7}
P416389	4.47×10^{-4}
P416489	6.10×10^{-6}
P416589	1.42×10^{-4}

The reported values are generally higher than the plant average of 2.1×10^{-4} cm/sec (see below), but are typical of the basal section of the Rocky Flats alluvium found in the West Spray field and other areas in the west side of the plant. The relatively high hydraulic conductivities and prevailing eastward groundwater flow direction imply that much of the lateral flux of groundwater into the southern half of the industrial area occurs beneath the IAW site.

Summary statistics for site-wide hydraulic conductivity data reported in the 1995 Hydrogeologic Characterization Report are as follows:

Unit	Geometric Mean (cm/sec)	Range: Minimum (cm/sec)	Range: Maximum (cm/sec)
Rocky Flats Alluvium	2.1×10^{-4}	7.1×10^{-8}	5.0×10^{-2}
No. 1 SS	7.9×10^{-4}	4.0×10^{-5}	9.3×10^{-3}
Weathered Claystone	8.8×10^{-7}	3.0×10^{-8}	5.6×10^{-4}

No hydraulic conductivity data exist for weathered claystone at the IAW site. A single unweathered bedrock hydraulic conductivity value of 6.6×10^{-6} cm/sec is reported for well P416989 located within the IAW site boundary. Because the bedrock consists mainly of claystone the bedrock is expected to exhibit hydraulic conductivities in the 10^{-6} to 10^{-8} cm/sec range.

Adequacy of Existing Hydrogeologic Database

The IAW site, like the IHSS 165 site, is situated in an area of divergent alluvial groundwater flow. This type of hydrologic setting increases the length of the downgradient facility perimeter which, in turn, increases the number of monitoring stations that are required to detect contaminant releases. The placement of existing monitoring wells is almost ideal for the proposed WMF. An estimated three additional wells will be required to fill data gaps as shown in Figure 6.

The adequacy of well screen placement is potentially a more serious matter for some of the existing well installations. In all of the existing wells, the screened interval consists of a 4.5 foot section of screen set at the base of the alluvium. These wells were originally installed as piezometers for monitoring water levels in the industrial area. In thickly saturated areas, such as found at wells P415889 through P416389, groundwater samples will be representative of the bottom of the alluvium. If contaminants are released from the facility, it is more likely that they will travel laterally across the upper portion of the saturated zone unless the leachate is significantly denser than the alluvial groundwater. The existing monitoring wells would consequently fail to detect a release. Installation of shallower paired well completions at many of the locations shown in Figure 6 may be required to ensure adequate monitoring of shallow groundwater at the site.

An estimated total of 13 wells will be required to monitor alluvial groundwater at the IAW site. If the existing 10 wells are deemed suitable for monitoring purposes, an additional three wells should be installed to complete the monitoring well network. As many as 10 new wells may be required if a portion of the existing wells are found to be unsuitable for contaminant detection monitoring purposes. In either case, the total number of wells monitored is not expected to exceed 13. Consideration should also be given to including seepage monitoring as part of the groundwater monitoring program.

Cost

The cost of additional investigation and monitoring well installation is estimated as follows:

Additional 3 wells

Drilling and Well Installation		$ 45,000
Sampling and analysis		$ 46,500
Reporting		$ 25,000
	Total	$116,500

Additional 10 wells

Drilling and Well Installation		$150,000
Sampling and analysis		$155,500
Reporting		$ 50,000
	Total	$355,500

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Attachments:
1.) Figures 1 through 6
2.) Water Level Correlation Charts
3.) Hydrograph Charts

cc:
W. R. Belcher
T. P. Lovseth
ERPD Records (2)

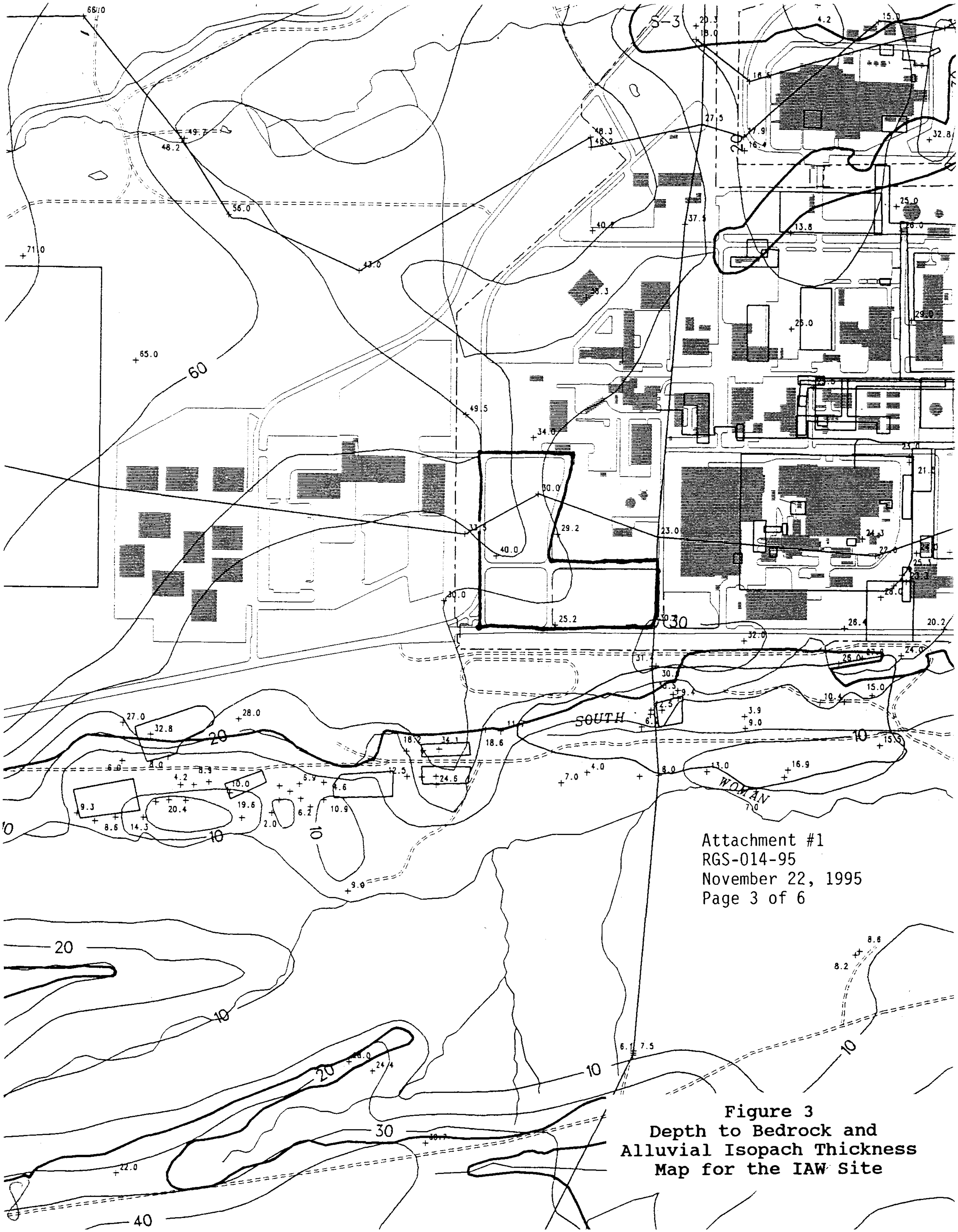

Figure 3
Depth to Bedrock and Alluvial Isopach Thickness Map for the IAW Site

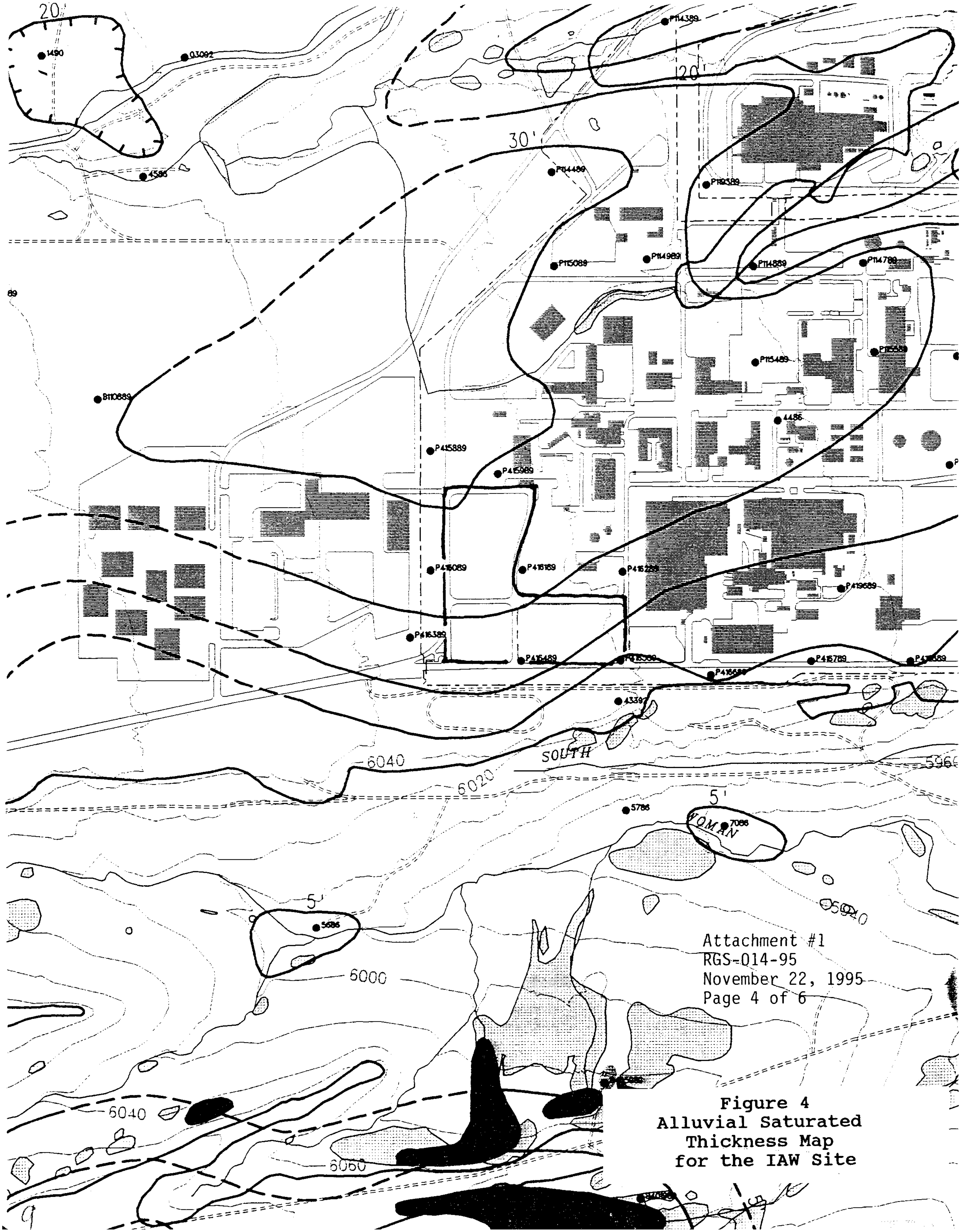

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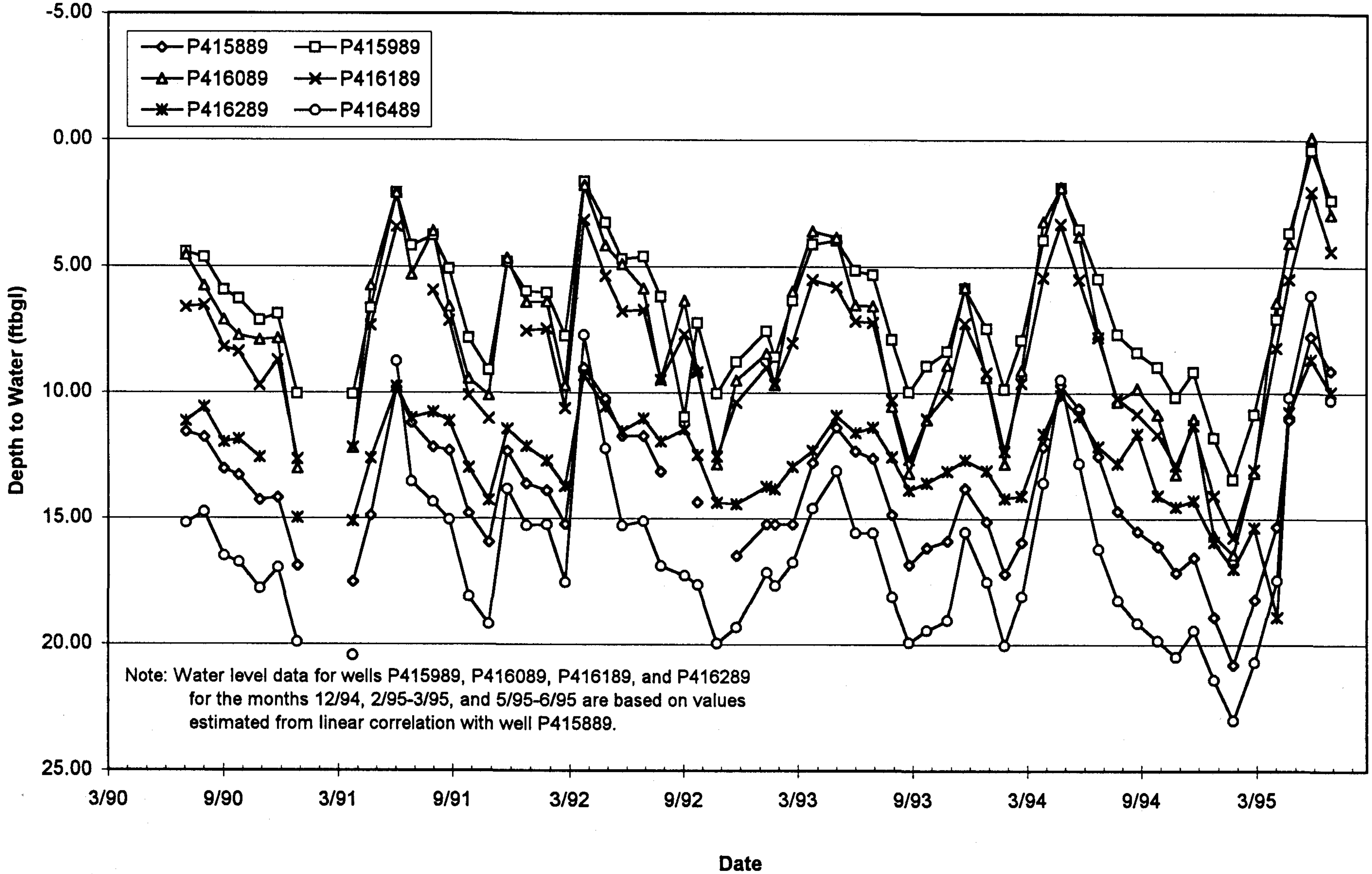
Figure 4
Alluvial Saturated Thickness Map
for the IAW Site

Figure 5
Hydrographs for Selected Wells at the Industrial Area West Site



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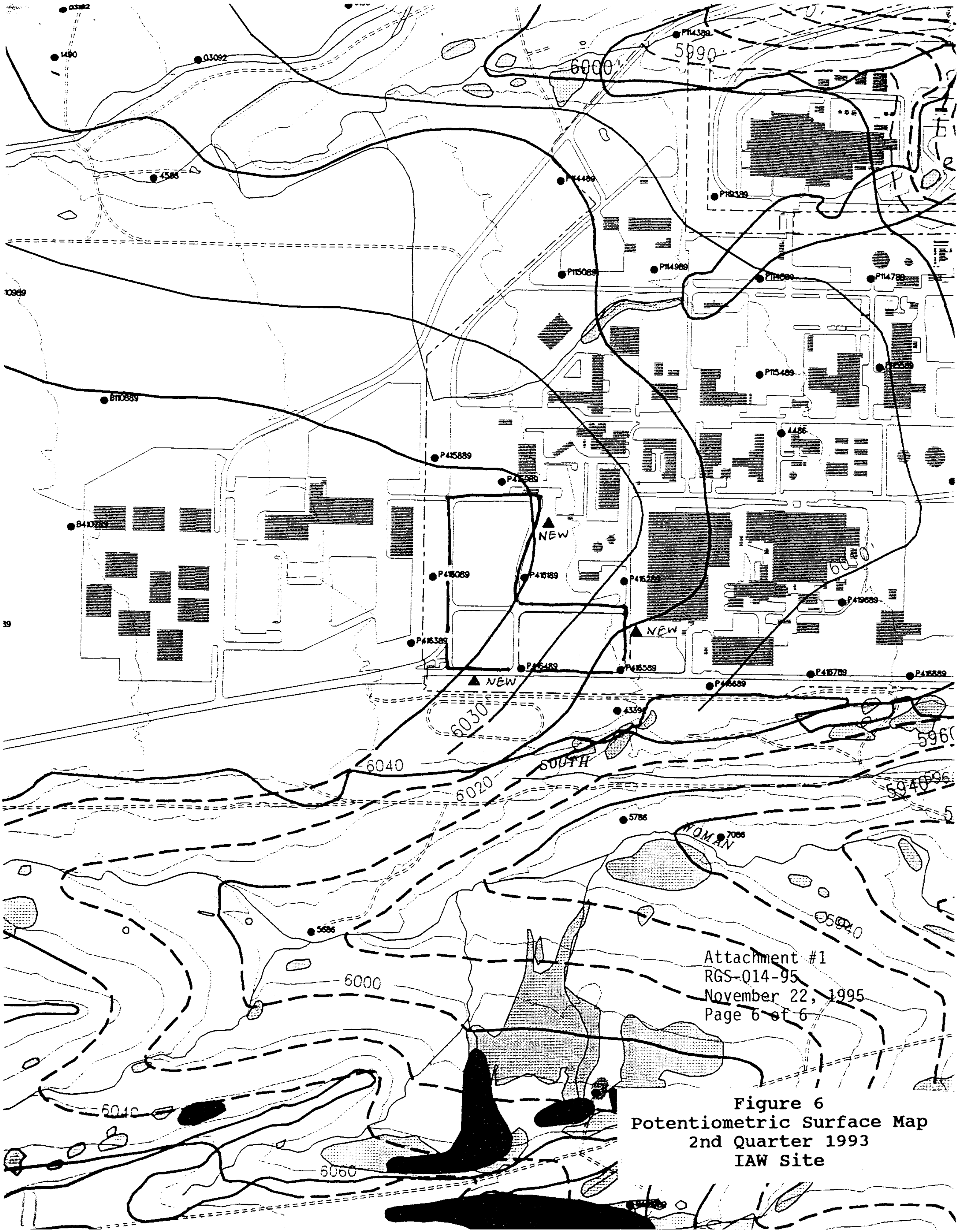

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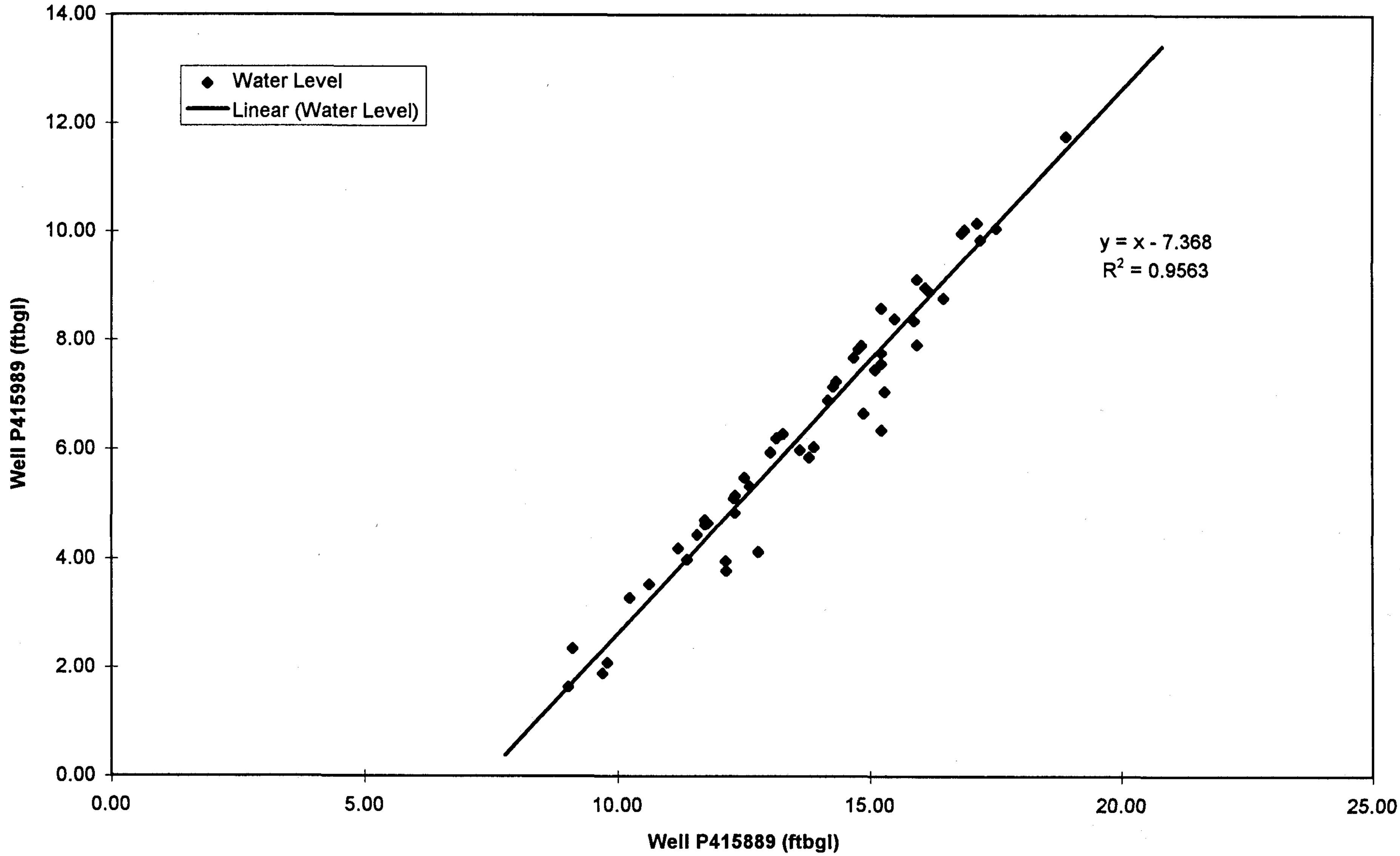
Figure 6
Potentiometric Surface Map
2nd Quarter 1993
IAW Site

Water Level Correlation Between Wells P415889 and P415989



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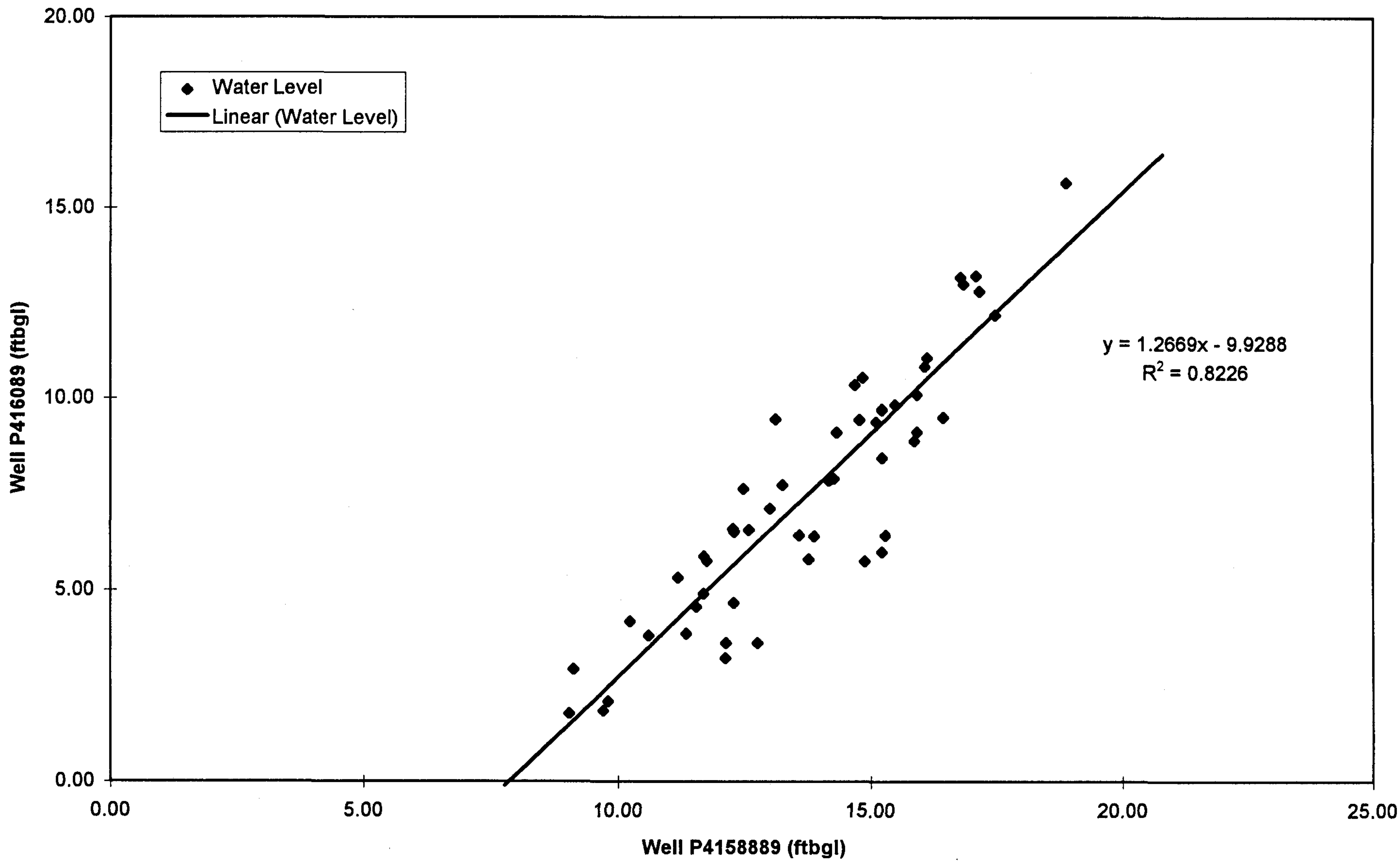
Water Level Correlation Between Wells P415889 and P416089



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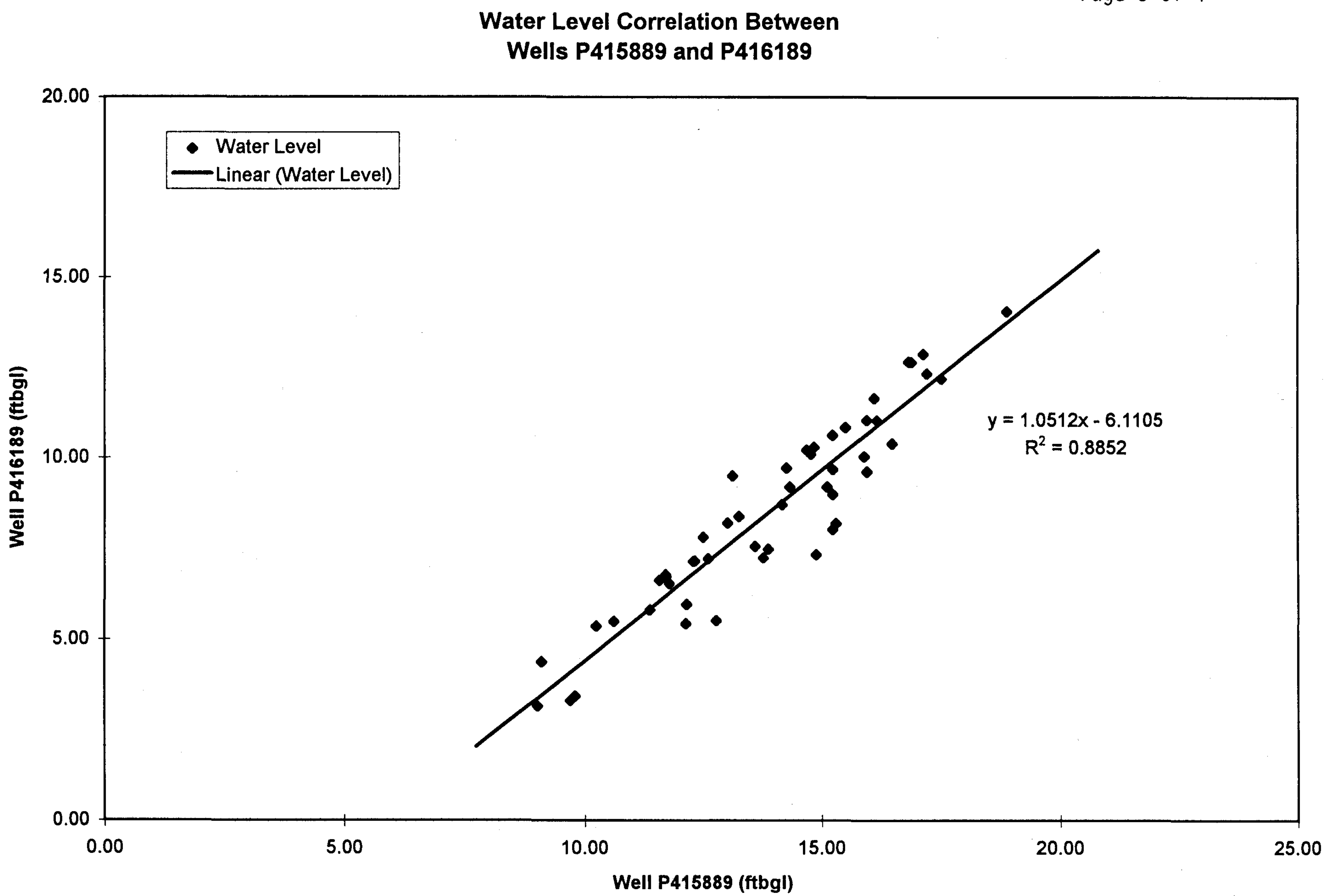
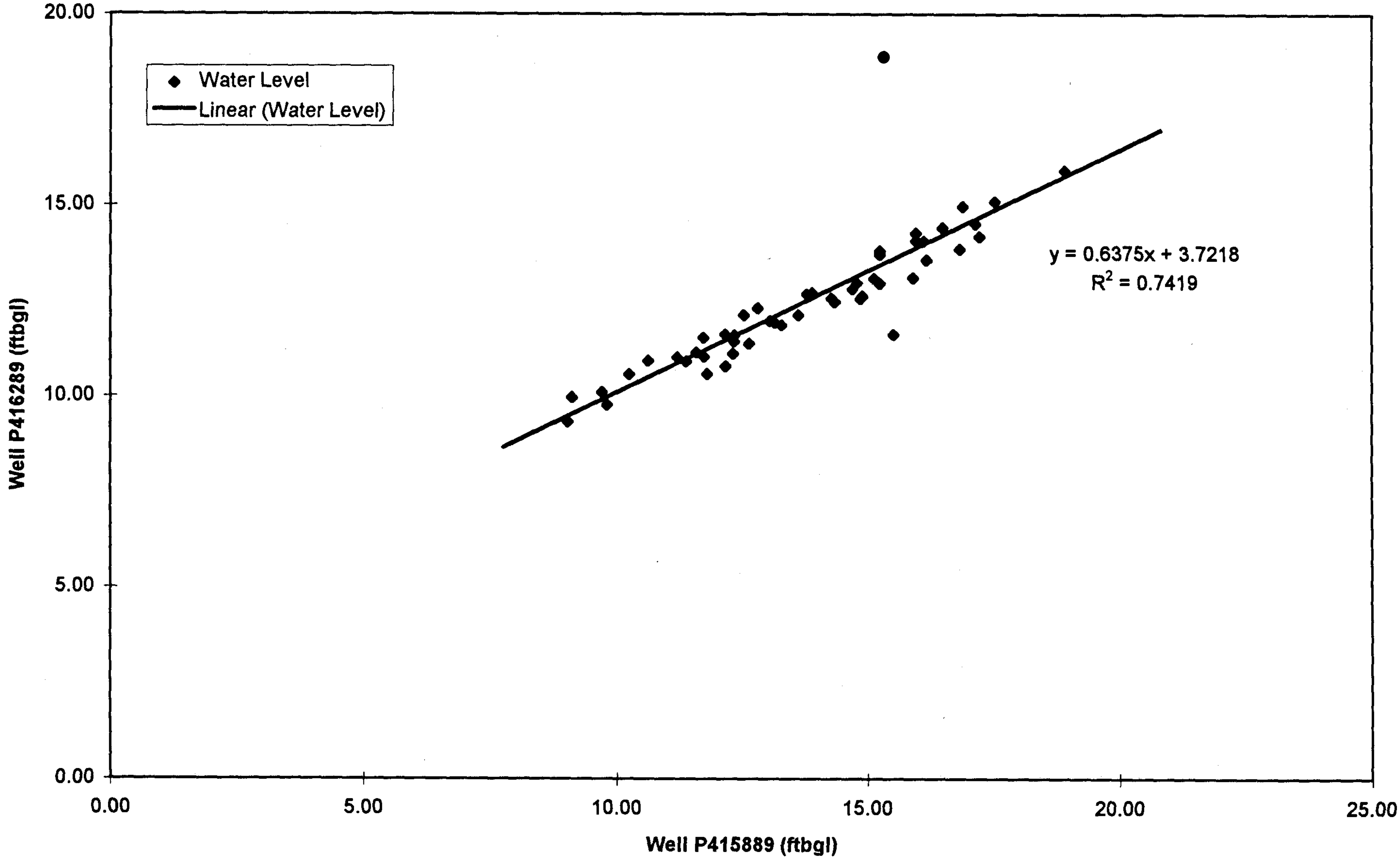

Water Level Correlation Between
Wells P415889 and P416189
Water Level
Linear (Water Level)
y = 1.0512x - 6.1105
R² = 0.8852
Well P416189 (ftbgl)
Well P415889 (ftbgl)
0.00
5.00
10.00
15.00
20.00
25.00

14

Water Level Correlation Between Wells P415889 and P416289



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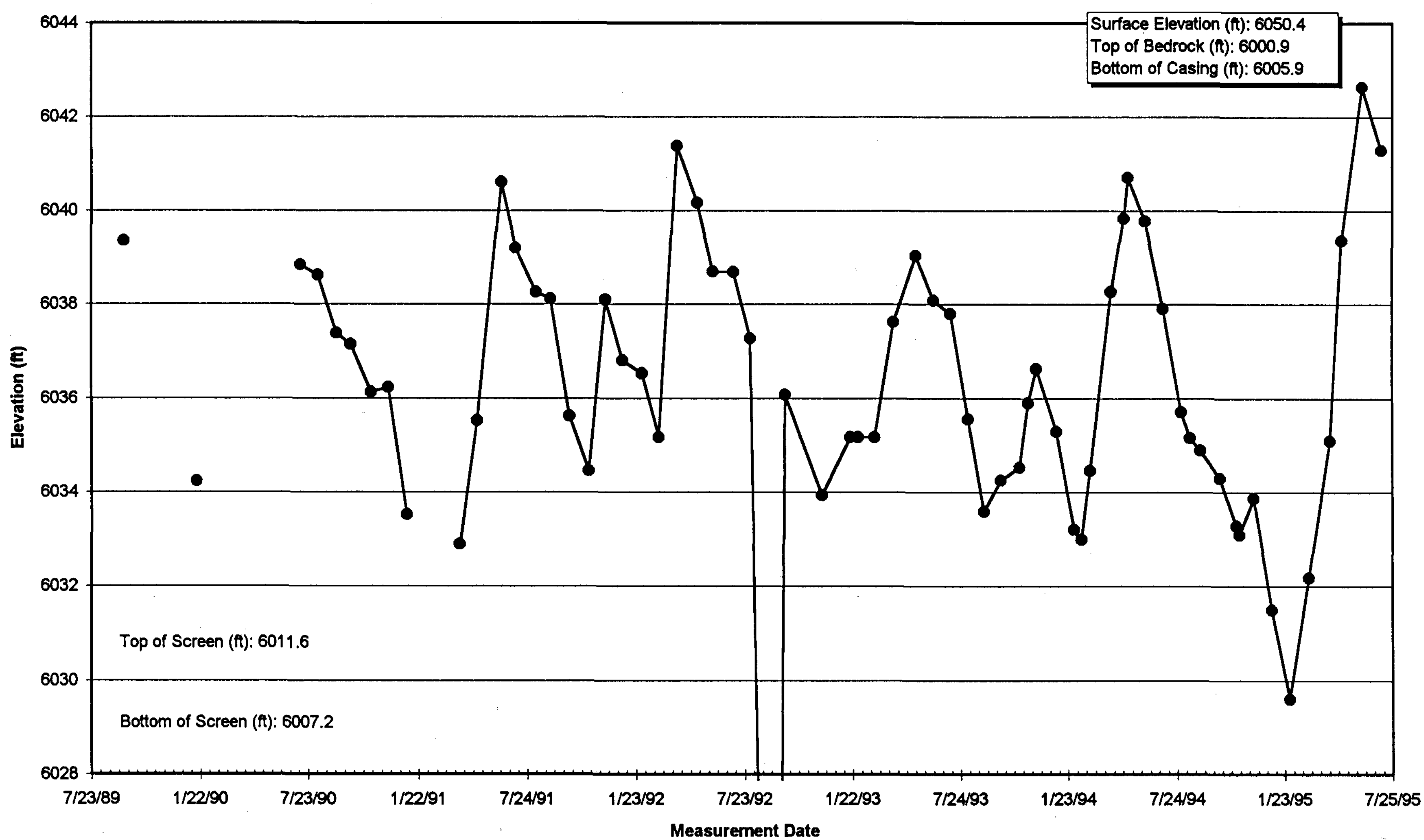
Hydrograph P415889



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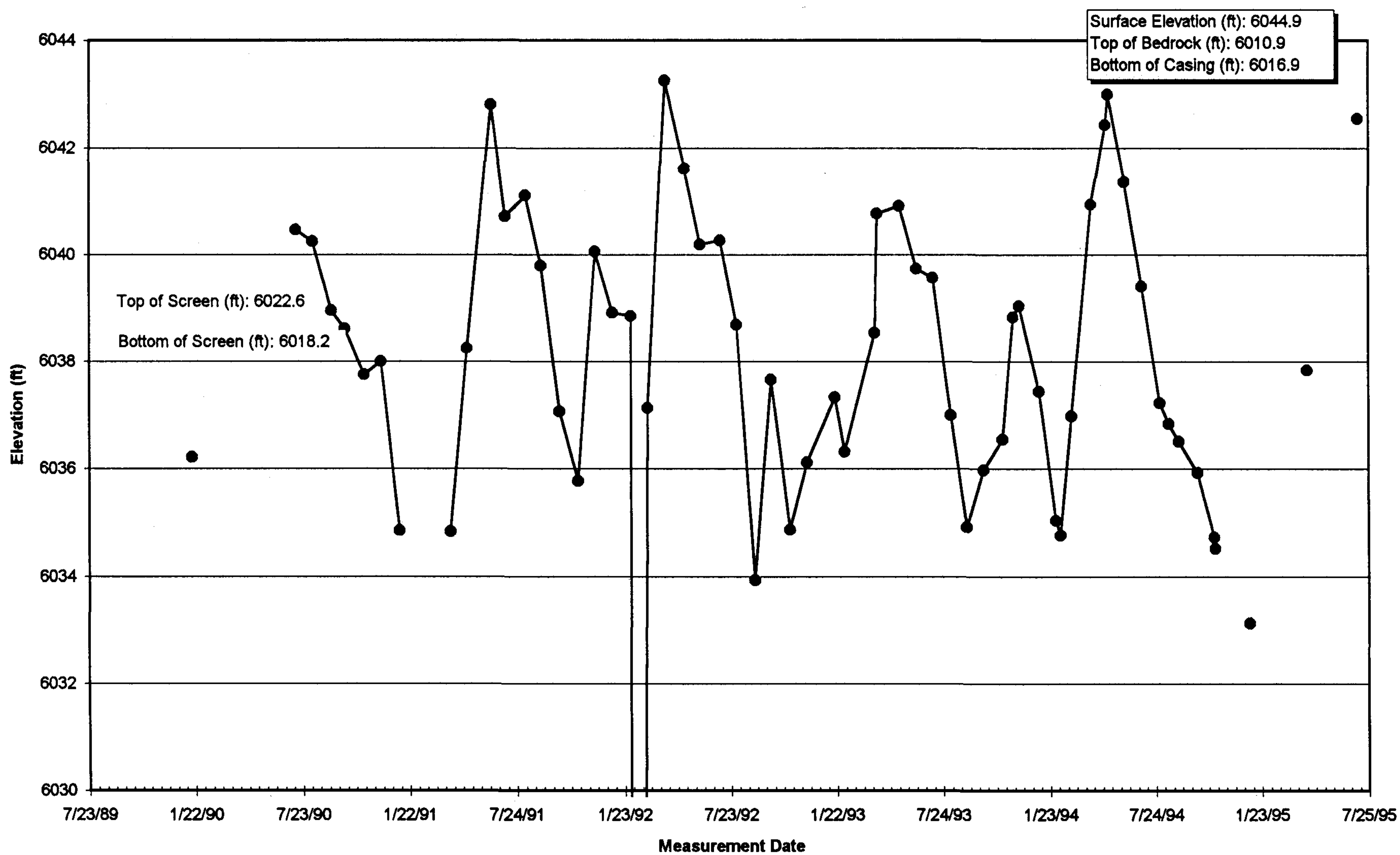
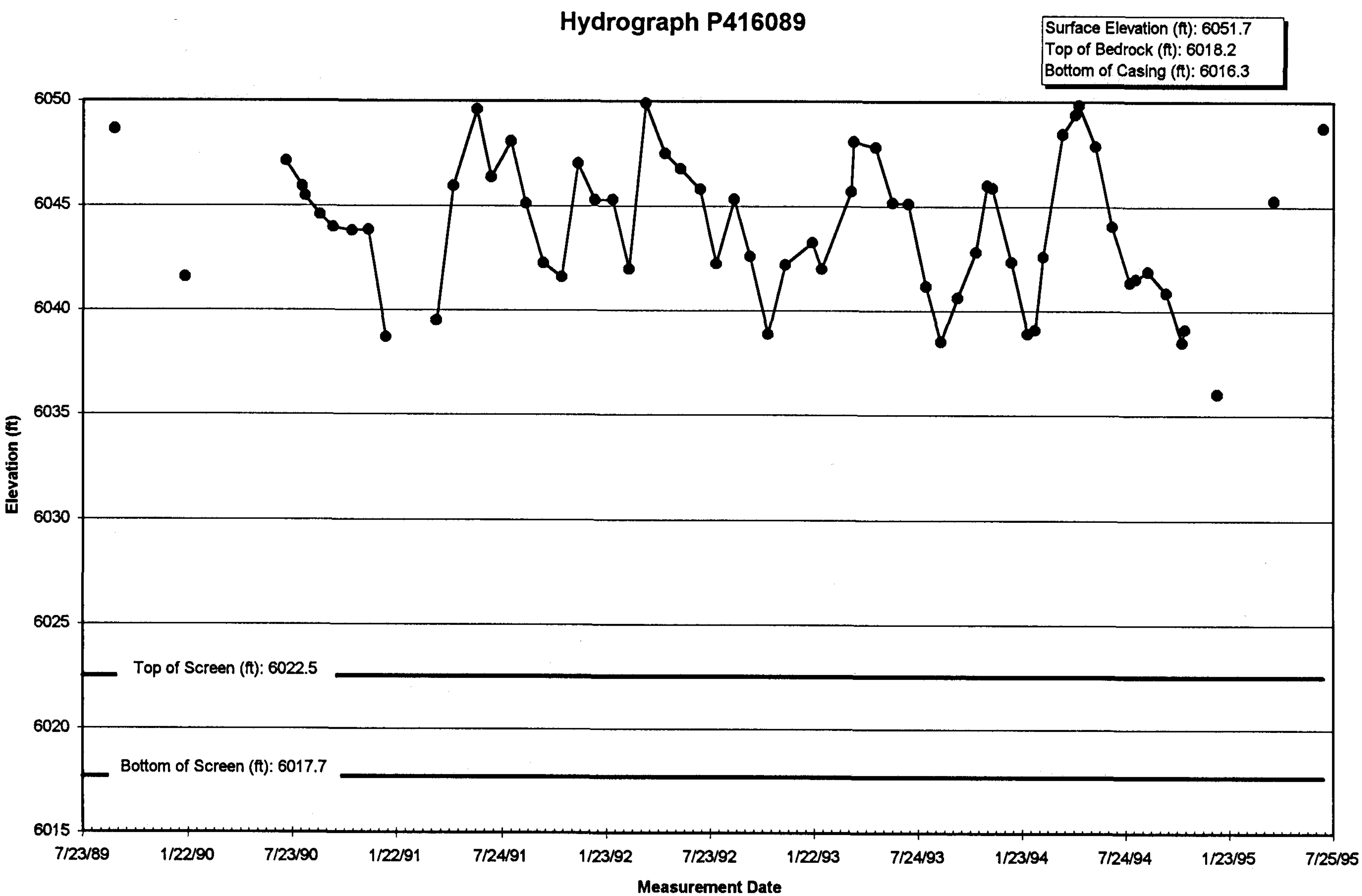
Hydrograph P415989




Hydrograph P416089
Surface Elevation (ft): 6051.7
Top of Bedrock (ft): 6018.2
Bottom of Casing (ft): 6016.3
Elevation (ft)
6050
6045
6040
6035
6030
6025
6020
6015
Top of Screen (ft): 6022.5
Bottom of Screen (ft): 6017.7
7/23/89
1/22/90
7/23/90
1/22/91
7/24/91
1/23/92
7/23/92
1/22/93
7/24/93
1/23/94
7/24/94
1/23/95
7/25/95
Measurement Date

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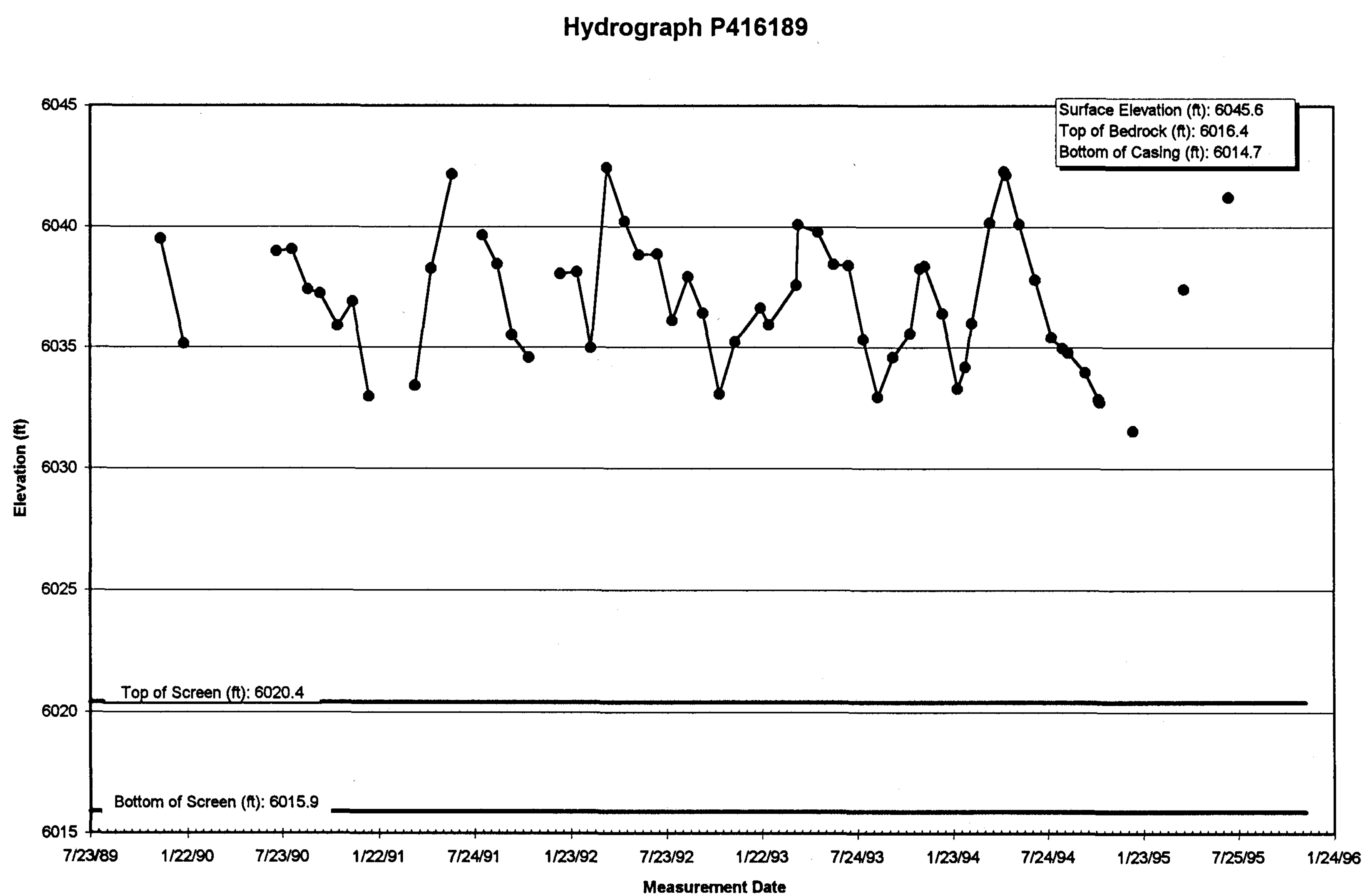
Hydrograph P416189
Surface Elevation (ft): 6045.6
Top of Bedrock (ft): 6016.4
Bottom of Casing (ft): 6014.7
Elevation (ft)
6045
6040
6035
6030
6025
6020
6015
Top of Screen (ft): 6020.4
Bottom of Screen (ft): 6015.9
7/23/89
1/22/90
7/23/90
1/22/91
7/24/91
1/23/92
7/23/92
1/22/93
7/24/93
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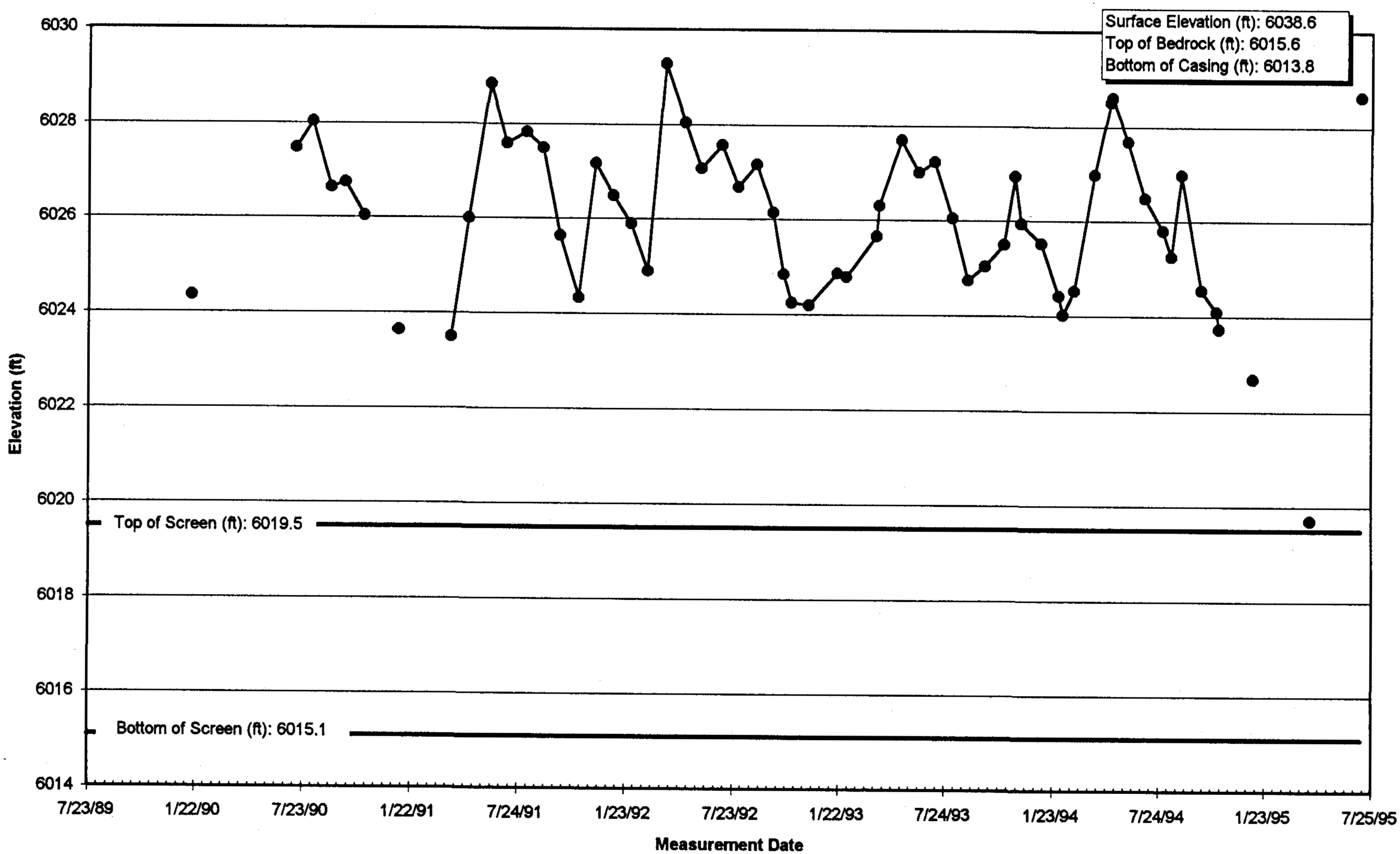
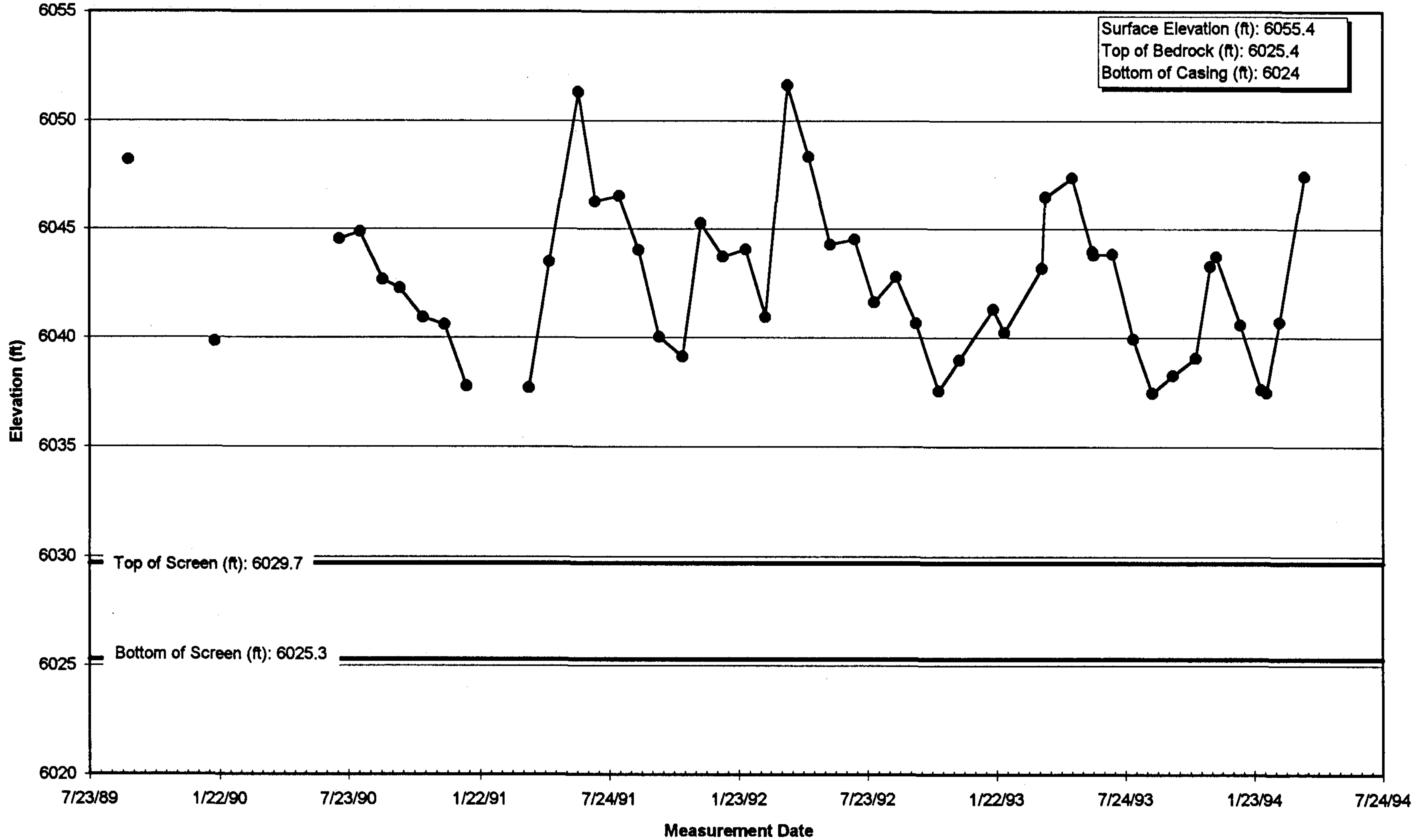
7/24/94
1/23/95
7/25/95
1/24/96
Measurement Date

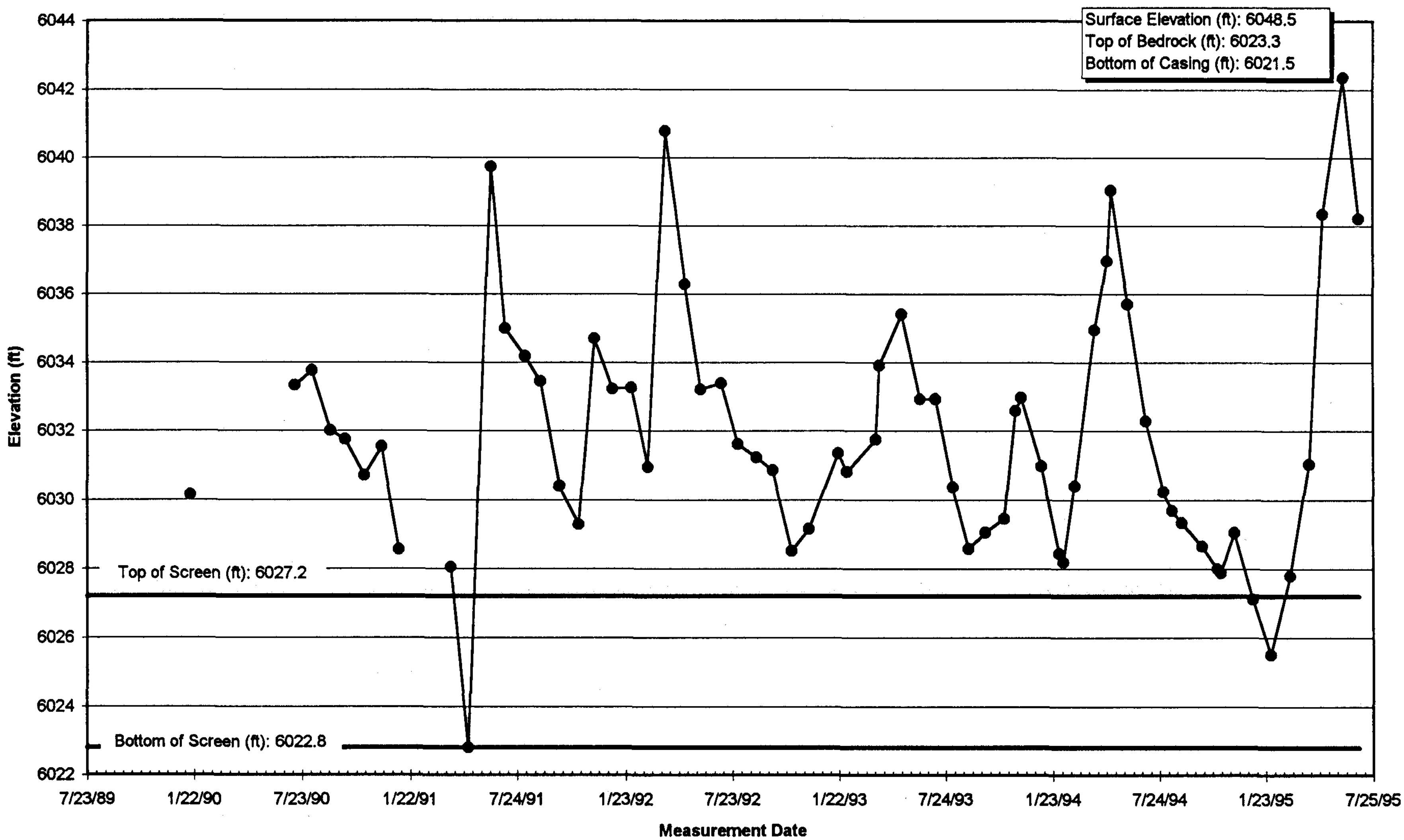
Hydrograph P416289



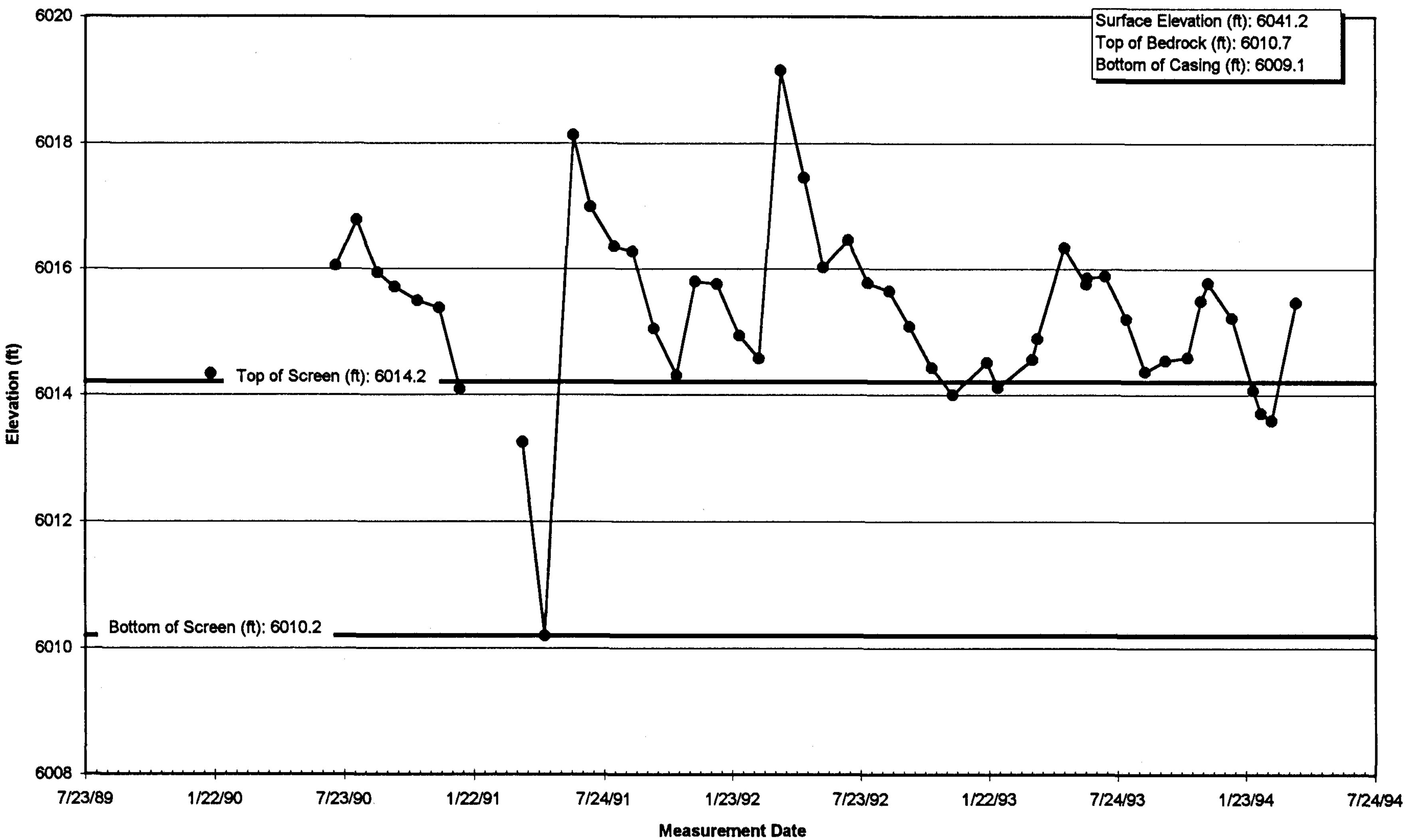
Hydrograph P416389

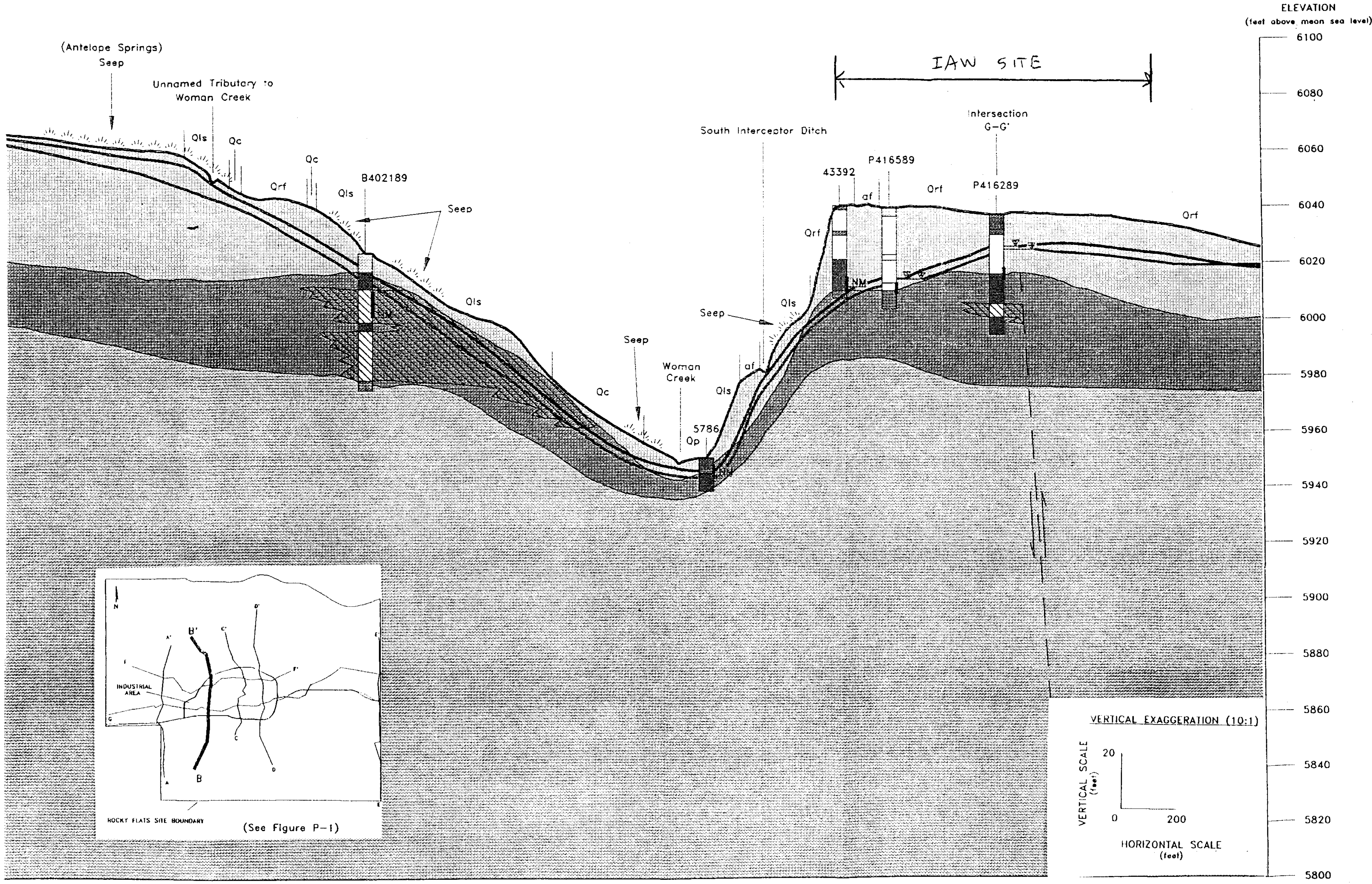


Hydrograph P416489



Hydrograph P416589





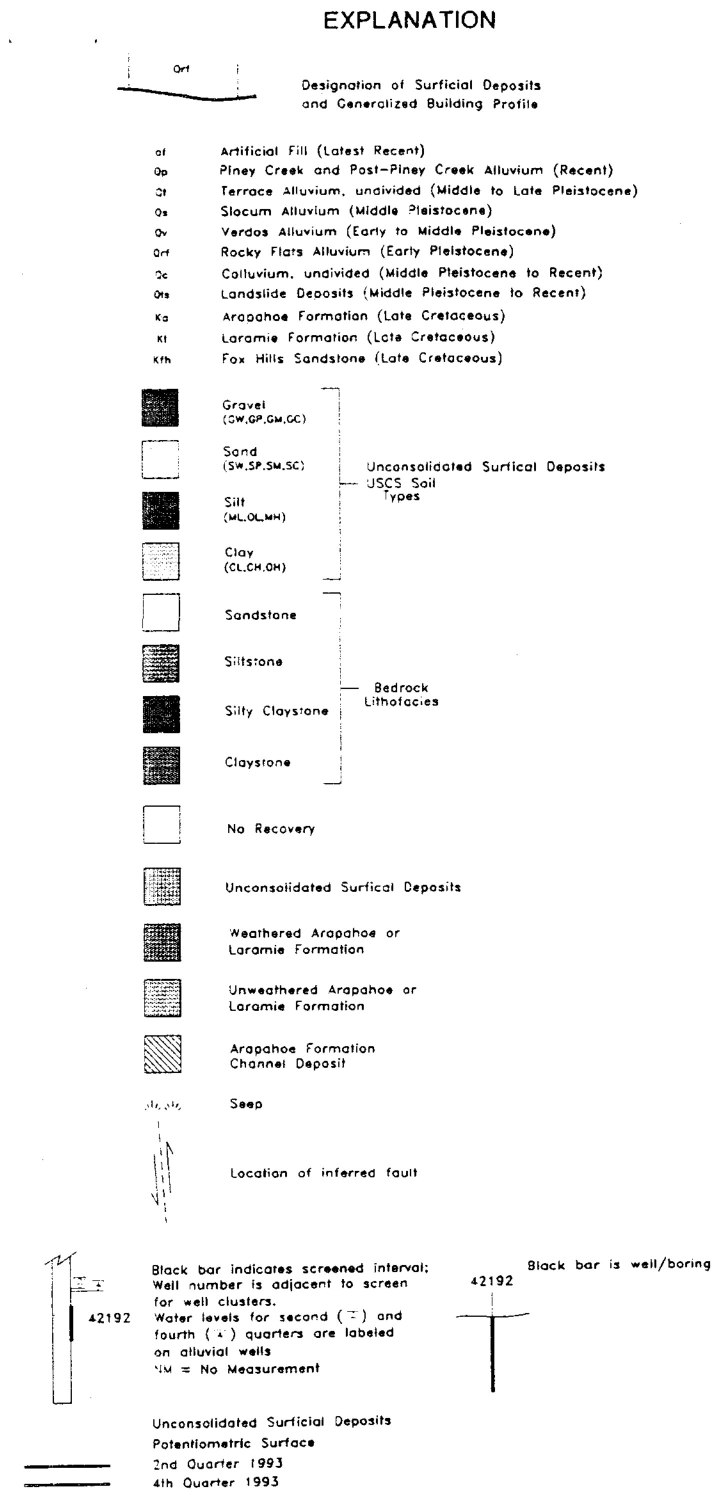


Figure 2
Segment of Hydrogeologic
Cross-Section B-B'
Showing the IAW Site Area

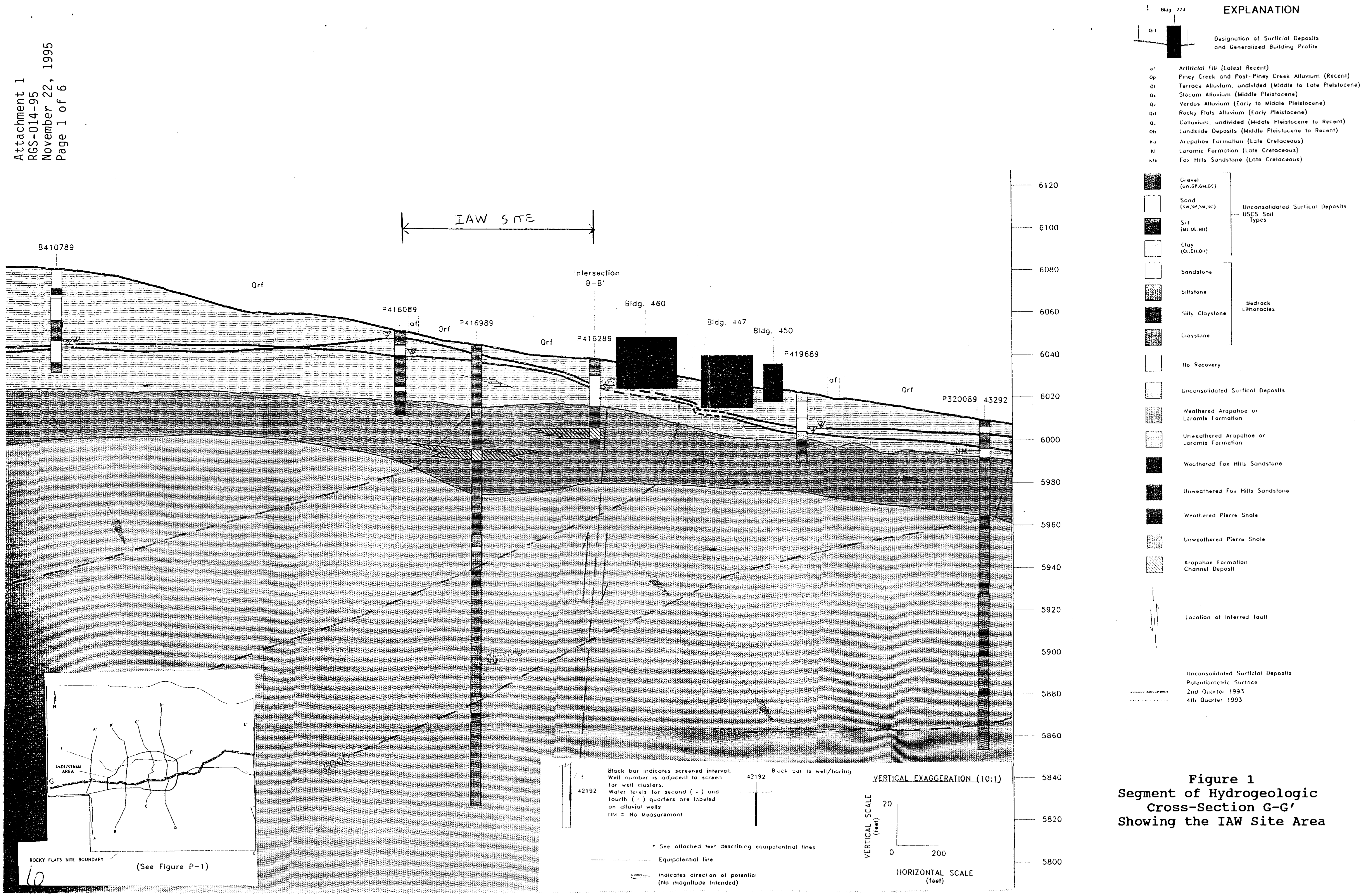


Figure 1
Segment of Hydrogeologic Cross-Section G-G' Showing the IAW Site Area